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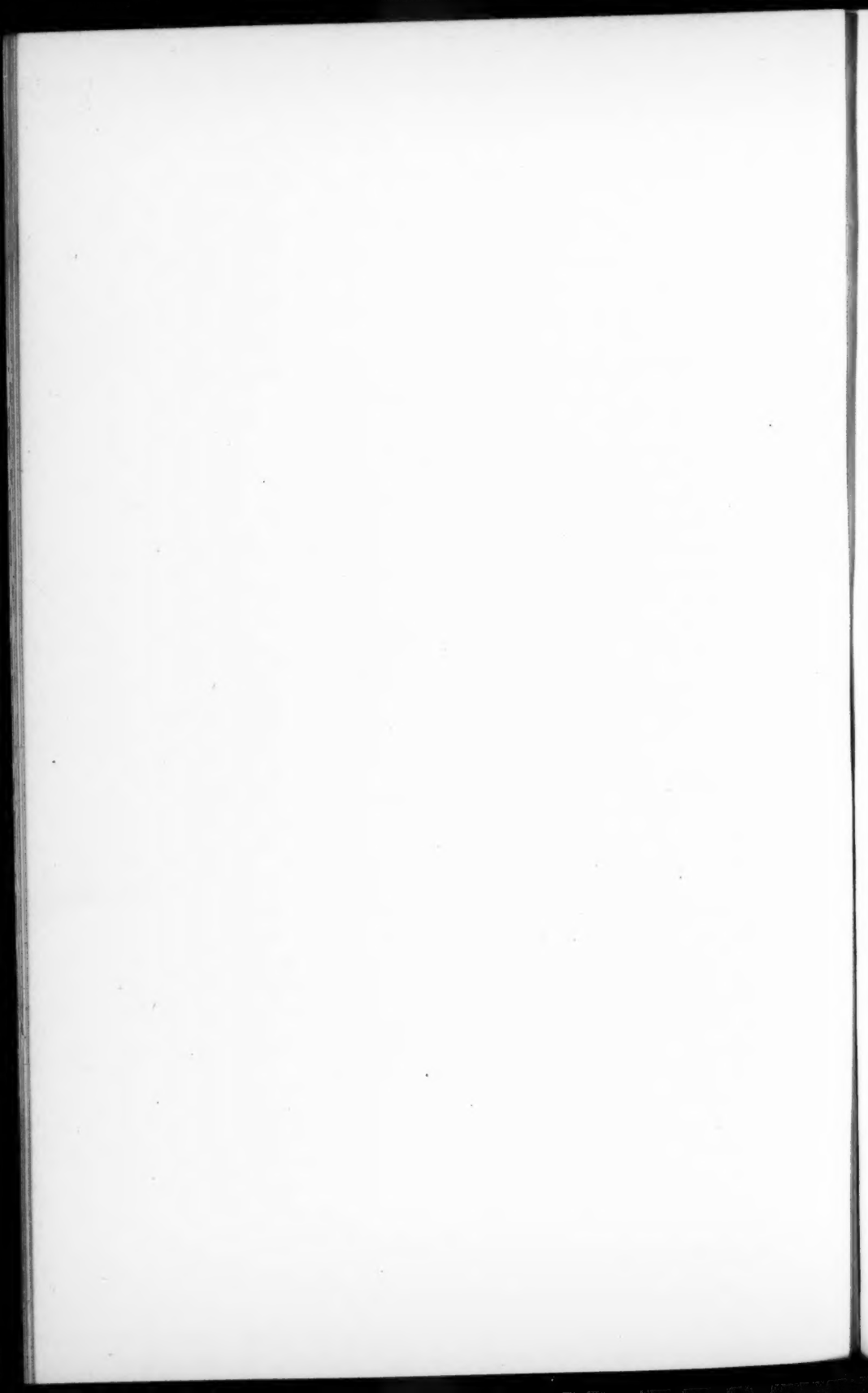
CONTRIBUTIONS FROM THE JEFFERSON PHYSICAL LABORATORY,
HARVARD COLLEGE.

ON THE PROLONGATION OF SPECTRAL LINES.

BY THEODORE LYMAN.

WITH A PLATE.

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ON THE PROLONGATION OF SPECTRAL LINES.

BY THEODORE LYMAN.

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INVESTIGATORS who have worked with concave diffraction gratings cannot have failed to observe the faint but sharp prolongations of strong lines which occur in the spectra produced by these instruments.

The cause of the difference in length of certain lines when a prism spectroscope is used is well known. Sir Norman Lockyer long ago made use of the phenomenon of "long and short lines" in his study of the chemistry of the Sun. He pointed out that when the vertical slit of the collimator is illuminated by the image of a light source formed by a lens, some of the lines in the resulting spectrum are longer than others. This of course arises from the fact that the portion of the source which illuminates the centre of the slit possesses some vibration frequencies which are wanting in those portions which come to focus at the top and bottom of the slit. When a concave grating is used, the astigmatism renders this phenomenon less striking.

The prolongations of strong lines which are referred to above present a different appearance, however, from those obtained with a prism spectroscope. They are, in fact, due to a different cause. As the author had never seen any explanation of the matter, it seemed that an investigation on the subject might prove of interest.

In making some adjustment of a concave grating of twenty-one foot radius the principal image of the slit came into view. It was at once noticed that this image was prolonged into two narrow streamers, one vertical and the other horizontal, each quite distinct and sharp. This suggested that the vertical continuation of the slit image and the vertical continuation of strong spectral lines were due to the same cause. Observations were accordingly made upon the principal image of the source. In order, however, to simplify the diffraction phenomena as much as possible, a circular opening of about 0.01 cm. diameter was substituted for the slit. In order to reduce spherical aberration to a minimum the light fell upon the grating at nearly normal incidence. In the final

observations the polished surface was always covered. The first photograph was taken with the grating in its normal position and with all the ruled surface exposed. The result is an image of the pin hole accompanied by two sharp streamers, one vertical the other horizontal. The horizontal streamer is the longer and stronger of the two. The effect is shown in the Plate, Figure 1.

If the ruled surface of the grating be protected by a screen having a rectangular aperture whose diagonal is less than the breadth of the ruled surface, the orientation of this aperture throws light upon the nature of the phenomenon. When the longest side of the opening is parallel to the longest side of the ruled surface, the image of the point source presents exactly the same appearance as when the whole grating surface is exposed. When, however, the aperture is set askew so that its sides make angles of 45° with the sides of the ruled surface, the effect on the image is striking. The result is shown in Figure 2. The vertical streamer has revolved through 45° and the horizontal streamer has been broken into two parts. One of these parts has turned through 45° while the other and longer part has remained fixed. The streamers which accompany the image seem then to consist of two components, one a cross which turns as the sides which bound the ruled surface turned, the other a horizontal line or streamer which remains stationary. The idea that the movable cross is due to diffraction through a rectangular opening at once suggests itself. This theory may be further tested by covering the grating surface by a screen with a circular hole. The image of the source so obtained showed no vertical streamer, the horizontal line was still present, though less intense. This result indicates that the explanation of the origin of the movable cross is the correct one.

When the point source was replaced by a slit, the effects were of an exactly similar character.

It is easy to apply the results of these experiments to the vertical continuation of strong spectral lines. In order to demonstrate that the vertical streamers are due to the rectangular shape of the ruled surface, we have only to cover the surface with a screen whose rectangular aperture is set askew with respect to the direction of the lines of the grating. We obtain the effect shown in Figure 3. Here the continuations of the strong lines have turned and broadened, though the lines themselves remain straight and sharp. The diffraction pattern from the rectangular grating aperture is no longer a cross with sharp vertical and horizontal arms. The cross has turned, and, since the aperture

is no longer symmetrical with respect to the slit, the arms have broadened.

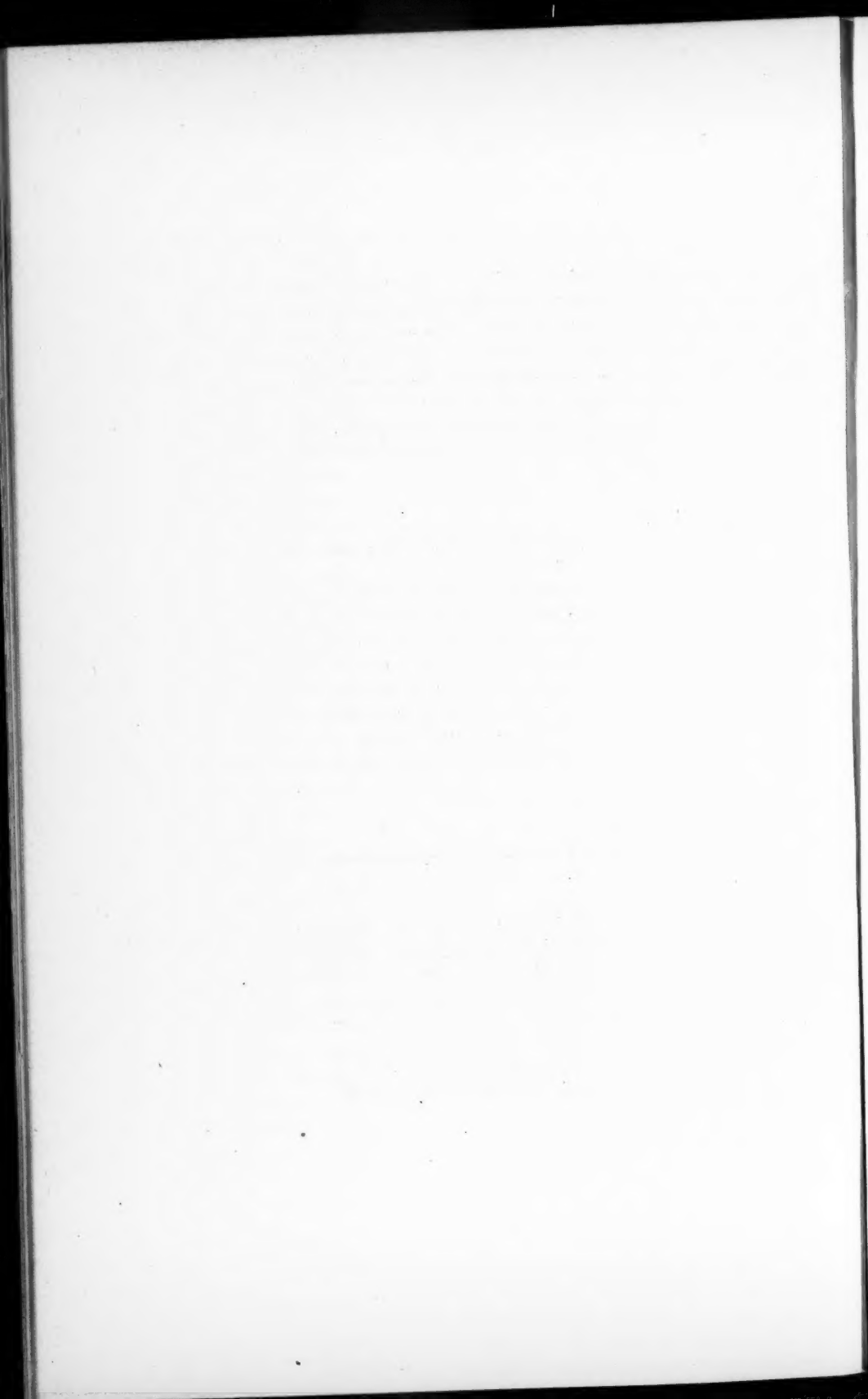
The horizontal band which does not turn as the aperture is rotated may be due to either of two causes, or to a combination of them. The subordinate or secondary maxima which accompany every line in the spectrum furnish the first reason, irregularities in the grating ruling furnish the second. The author has shown that these irregularities may not only furnish a background, but, under favorable circumstances, may even produce sharp reproductions of real lines. The background or nearly continuous band can be noticed with almost every grating, and can be best observed in that portion of the extreme ultra-violet where no real lines are obtained. Its intensity varies greatly with different gratings. In investigations where long exposures are necessary it often proves very inconvenient, for faint real lines are much obscured by its presence.

In many cases the horizontal band due to diffraction through a rectangular opening is much stronger and more troublesome than the band due to irregular ruling. In this case there is a remedy at hand. The ends of the ruled space may be covered with slanting pieces of blank paper and the rectangular ruled space thus converted into a parallelogram. The effect of this arrangement is to revolve the horizontal streamer due to the shape of the opening, the vertical streamer remaining fixed, with the result that the background of the spectrum is very materially cleared. The author can recommend this device to all those who investigate faint spectral lines, and to whom a clear field is a necessity.



FIGURE A.

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LYMAN.—SPECTRAL LINES.



FIG. 1.

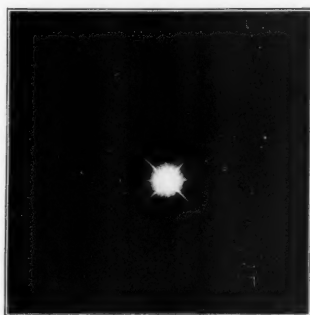


FIG. 2.

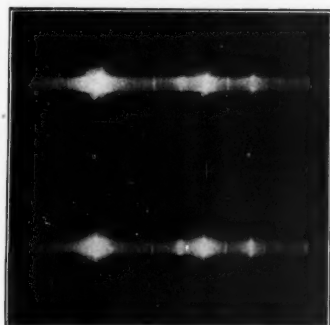


FIG. 3.